

THE ELECTRONIC VOTING ADMISSION USING A CELL PHONE AND ITS EVALUATION

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ABSTRACT

The electronic voting in the voting place has been realized in some local government in Japan. However, The electronic voting admission has not been developed. This paper proposes a method for the electronic voting admission tickets by email using a cell phone. This method can coexist with the current voting admission ticket by postal mail. A two-dimensional symbol is used for the format of the communication data from the server to the cell phone, and also the communication data between the cell phone and the terminal in the reception desk of the voting place. To keep the privacy and security of the voter, the encryption and authentication techniques are used. According to the cost evaluation, the cost for voting admission remarkably decreases by using the proposed electronic voting admission ticket. The prototype using a server, a notebook PC, a two-dimensional symbol scanner, and a cell phone has been developed and evaluated.

KEYWORDS : *Voting, Voting Admission Ticket, Cell Phone, Two-Dimensional Symbol*

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1. INTRODUCTION

Electronic-voting has a high degree of expectation on a global basis, as a method of sustaining the future democracy. For example, it is advocated that this system is being developed with such steps as electronic-voting inside voting place in the first stage, selecting a voting station arbitrarily by networked stations in the second stage, and then, voting at any arbitrary place in the third stage.

Such an off-line electronic voting is implemented by a small number of local governments of Japan, which is operated inside their voting place by IC card and single purpose-terminal for voting (such as touch panel). Such a voting system is currently undertaken for national and municipal elections, regardless of the existence or nonexistence of electronic voting function at the above voting place, which is implemented by the way that election officials mail admission cards of voting station (numbered ticket of voting station) to each constituent household, and these voter take the card to the designated station and exchange the card for voting paper at the acceptance and cast a ballot (there are some differences by local government).

Therefore, digitization has yet been brought to realization of the admission card of voting station (numbered ticket of voting station).

The display of two-dimensional code on cell-phone handset is available for the electronic money for merchandise buying from vending machines, electronic tickets for airline and others, and electronic coupons for shopping.

By displaying two-dimensional code on the screen of cell-phone handset, computer processing can be made by reading two-dimensional code via two-dimensional scanner. And also, the security of two-dimensional code can be strengthened by secret code and authentication function. Investigations are now carried out by Mr. Ito and other persons³⁾ into the display on cell-phone handset by using special image pattern, instead of the two-dimensional code. However, as it is necessary to develop a new special scanner in order to read the new special image pattern by CCD camera and others and to decode it at a high speed, it results in a high cost method. Of the two-dimensional code, scanners for cell-phone handset are available on the open market at a relatively low cost. This paper submits the proposal of digitization of the admission card of voting station by using cell-phone and the two-dimensional code, and of the utilization of this electronic card as the admission card of voting station. And, this paper considers the processing method, the extension to other than the two-dimensional code regarding the communication method of cell-phone handset and terminal, prototype and its cost-effectiveness. (Additionally, the electronic admission card of voting station may be referred to as “electronic admission card.”)

2. VOTING ADMISSION TICKET

2.1 Processing Mode

In case that voter desire to receive the admission card of voting station via cell-phone, they give notice in advance their e-mail address to their election committee. Election administration server sends such voter at the cell-phone handset, of the enciphered information and authentication data of the voter as electronic admission card, as well as the character data with the information (the name of voter, voting station and others) equivalent to the paper-made admission card of voting station, and simplified map to the station.

Voter present their cell-phone handset to the person in charge of acceptance at the voting station. The acceptance terminal receives the electronic admission card from the cell-phone handset and verifies its correspondence with the information of the voter (birth date (age), sex, address) which has been downloaded in advance from the terminal at the station, and then it displays the result of the verification.

Processing Content

In case that admission card of voting station is brought to realization in the form of two-dimensional code, the example of procedure is as follows for the implementation of the proposed method.

An example of the displayed the elements of the proposed voting admission ticket system by using a cell phone. is shown in Figure 1.

(MAC: Message Authentication Code.)

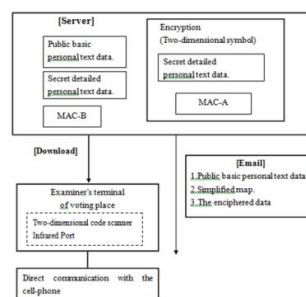


Figure 1: The Elements of the Proposed Voting Admission Ticket System by Using a Cell Phone

The Server of Election Officials Sorts

- The server of election officials sorts out the data of voter into the both of the character basic information (name, user ID, affiliation) of voter for the display on cell-phone handset and the character detailed information (name, user ID, affiliation, birth date, sex, telephone number, address, preparation date, expiry date and other additional information) of voter for storing the two-dimensional code, and makes them the authentication data of registered voter.
- The server makes the calculation of message authentication (or digital signature) of the stored two-dimensional code information (character detailed information of voter) and prepares the authentication unit A.
- The server makes the calculation of message authentication (or preparation of digital signature) of cell-phone handset and common delivery information (character detailed information of voter) to examiner terminal, and then prepares the authentication unit B.
- The server enciphers the “character detailed information of voter, authentication unit A.” and stores it in the two-dimensional code.
- The server sends the “character basic information of voter, two-dimensional code” to cell-phone handset. This data is sent by e-mail to the cell-phone handset of users, or downloaded by the users’ accessing to the server via the browser of cell-phone handset.

The keys of secret code and authentication are to be held jointly in the server and in the acceptance terminal of voting station.

(Explanation)

Sorting-out of the character data of voter into the character basic information of voter and the character detailed information of voter. The aim of this sorting-out is for the improvement of safety by way of enciphering the character detailed information of voter and storing it in the two-dimensional code. The character basic information of voter can be displayed on the screen of cell-phone handset by being sent to the cell-phone handset without any enciphering.

By the method of using e-mail in order to sending the authentication data of voter from server to cell-phone handset, it is currently difficult for the most of cell-phone handsets to fully encipher the contents of the e-mail between server and cell-phone handset. Then, the risk of monitoring is taken into account of other than the data which is enciphered by the two-dimensional code. (Additionally, in case of accessing via browser from cell-phone handset, the communication data can be enciphered by way of SSL (Secure Sockets Layer) protocol and others.)

2.2 Processing Content of Cell-Phone of Constituent

- Voter receive the authentication data of voter for delivery use at their cell-phone handset from the server.
- Voter present their cell-phone handset to the person in charge of acceptance, following his/ her instructions at voting station.

2.3 Processing Content of Acceptance Terminal at Votings Station

- Person in charge of acceptance downloads “the character detailed information of voter, the authentication unit A

and unit B” to the acceptance terminal from the server, as the authentication data of voter for acceptance terminal use, and then examines the validity of the authentication unit B (the security is protected by such secret code / authentication as SSL protocol and others, between the server and acceptance terminal at voting station).

- Person in charge of acceptance receives at acceptance terminal, the electronic admission card from users’ cell-phone handset by the form of two-dimensional code.
- Acceptance terminal examines the correspondence of the authentication unit A which is obtained from the two-dimensional code at cell-phone handset, with the authentication unit A which is obtained from the server.
- Acceptance terminal examines the authentication unit A by the authentication unit and the content data of the two-dimensional code, which are obtained from the two-dimensional code at cell-phone handset.
- In case that the above examinations have posed no problems regarding the authentication unit A and B, acceptance terminal displays on its own terminal, such authentication data of voter for acceptance terminal use ,which are obtained from the server.

2.3 A Direct Communication Method between Cell-Phone and the Acceptance Terminal at Voting Station

As a direct communication method between cell-phone handset and the acceptance terminal at voting station, there are two-dimensional code scanner, Infrared Port, noncontact IC card built-in a cell-phone handset or Bluetooth.

2.3.1 The Two-Dimensional Code Scanner

By way of putting users’ cell-phone handset close to the two-dimensional code scanner, the two-dimensional code is scanned without any contact, which is displayed on the screen of cell-phone handset.

Merit: It can be applied for the largest number of cell-phone handsets at this time.

Demerit: The display of the two-dimensional code is required on the screen of cell-phone handset. The price of the two-dimensional code scanner is relatively expensive.

2.3.2 The Noncontact IC Card of the Built-in a Cell-Phone Handset (Electromagnetic Induction or an Electric Wave)

By touching the certain part of users’ cell-phone handset on the read writer of noncontact IC card, the authentication data of voter is scanned.

Merit: User-friendliness.

Demerit: There are few models of cell-phone handset which are applied for this function. As the antenna built-in a cell-phone handset is small, it requires to be put close to or to be touched the read writer of noncontact IC card.

Infrared Communication

The authentication data of voter is received at Infrared Communication Port from users’ cell-phone handset.

Merit: It can extend the distance between cell-phone handset and Infrared Communication Port (several 10cm).

Demerit: There are few models of cell-phone handset which are applied for this function. Directionality is strong to Infrared Port.

Bluetooth

The authentication data of voter is received at a receiver attached to the terminal by Bluetooth radio waves from users' cell-phone handset.

Merit: User-friendliness.

Demerit: There are few models of cell-phone handset which are applied for this function. As the footprint of waves is wide (several 10 m), it is in danger of being sniffed.

It can be applied for various methods of communication to utilize the data in the format of two-dimensional code as communication data. (However, it may not be in the format of two-dimensional code, when other methods of direct communication are used, excepting the two-dimensional code). Such a method can be applied for the largest number of cell-phone handsets at this time, which scans the two-dimensional code displayed on a cell-phone handset by putting two-dimensional code scanner close to the cell-phone handset. It can be applied for various methods of communication to utilize the data in the format of two-dimensional code as communication data. (However, it may not be in the format of two-dimensional code, when other methods of direct communication are used, excepting the two-dimensional code).

The Effect of Voting Admission Ticket

Followings are the issues regarding the existing paper-made admission card of voting station, and the effects of the electronic admission card of voting station.

- Voter may lose their admission card of voting station, as the delivery of card is made earlier than the voting day.
- This issue can be solved by storing the electronic admission card in a cell-phone handset (in case that voter have lost their cell-phone handset, they go to their voting station without their electronic admission card. This is same to the case when they have lost their paper-made admission card of voting station.)
- Voter may go to different voting station which is not designated, as plural voting place are put in the simplified map.
- This issue can be solved by putting the map of one voting station on the electronic admission card.
- There is some time zone when waiting time for acceptance is lengthened at the voting place which handle many voter, as the checking is made by hand of the each name of voter with that appeared in the bulky registration list.
- This issue can be solved by accelerating acceptance process, due to the way of searching registration list by the electronic admission card.
- The printing / mailing costs are huge of the admission card of voting station, because of many voter
- The effect on this issue is stated in the Section 4.

4. A COST CUT EFFECT BY THE VOTING ELECTION ADMISSION TICKET**4.1 The Element of the Cost in the Voting Admission Ticket**

Consideration is made of the cost in order to examine the improvement effect on the above-mentioned issue. The comparison of cost for the voting admission tickets is shown in Table 1.

Table 1: The Comparison of Cost for Voting Admission Tickets

Elements of cost	Voting electronic admission ticket	Voting admission ticket of the paper
The election administration server	Necessary.	Necessary.
The print of the voting admission ticket	None	Necessary.
The delivery of the voting admission ticket	Email	Postal mail
The voter's payment for the voting admission.	A little payment occurs when the voter receives the email.	None.
The time and transportation expenses for the voter.	Necessary.	Necessary.

4.2 The Increase Cost of the Voting Electronic Admission Ticket

Consideration is made of the increased cost regarding the electronic admission ticket of voting station. As the electronic admission card of voting station is composed of the character basic information of voter (text data), map to voting station (line drawing) and the two-dimension code, its total volume is small. Therefore, such data are sufficiently-small, which are sent to a cell-phone handset from the server. The details are as follows;

(1)Example of Prototype Data

Followings are data volume of the electronic admission card of voting station which is sent to one constituent at his/her cell-phone handset.

Character data (voting date and hour, constituent name, voting station and others): 98 byte

Simplified Map Data: 526 byte

Two-dimension Code: 550 byte

Total of the Above: 1,174 byte

(2)Total Packet and Rates of the Electronic Admission Card of Voting Station

1 packet = 128 byte

If the header length for system use in packet is assumed 8 byte, the data for user use in one packet is 120 byte / packet.

Therefore, 1,174 byte is equal to approx. 9.78 packets. The packet rates differ by cell-phone service provider and service, of the electronic admission card of voting station. For example, as the typical example of packet telecom rates, in case of 0.21 yen (including tax) / packet, the rate paid by server is nil and approx.2.00 yen by cell-phone holder (constituent). (This rate is a fine cost, considering the cell-phone rate per user (more than several thousand yen))

The Decreasing Cost of the Electronic Voting Admission Ticket

Of a certain local government (city (prefectural seat)), calculation is made of such costs of admission card of voting station which were paid for the Upper House regular election held in July, 2004 (based on the data released from election committee).

The printing / mailing costs of the admission card of voting station per constituent □ 31.155 (yen / constituent)

This value is assumed close to that of the national average. Total number of voter across the nation is 103,273,872 as of 29, August, 2005 (date released from the Ministry of Internal Affairs and Communications).

Therefore, approx. 3.2 billion yen is paid for the admission card of voting station at each election.

In case that all of the voter across the nation use the admission card of voting station, the printing / mailing costs of approx. 3.2 billion yen can be reduced to nil.

4.4 A Cost Cut Effect by the Election Number of Times

4.4. 1 The Number of Times of the National Election

As the life of Parliament is four years (the Diet may be dissolved, by the Constitution) of the members of the House of Representatives, the election of the members is held every two or four years. This is equal to approx. 1/3 (number of times / years). As the life of Parliament is six years of the members of the Upper House and the half of the Upper House seats are to be contested by election every three years (by the Constitution). This is equal to approx. 1/3 (number of times / years).

Total number of the elections of both members is approx. 2/3 (number of times / years). Therefore, the national election is held approx. 20/3 (number of times) for ten years.

4.4. 2 The Number of Times of the Local Election

Of prefectural members, the life of Parliament is four years for the chief of each prefecture and for local assemblymen (by the Local Government Law). Of municipality, the life of Parliament is four years for the chief of each municipality and for local assemblymen (by the Local Government Law). Of wards, the life of Parliament is four years for the chief of each ward and forward assemblymen (by the Local Government Law).

Of the elections of prefecture and municipality / ward, one constituent goes to the polls of the both elections. Further, as the both elections are generally held in a separate time, the number of elections are 1/4 (number of times / years) each. Therefore, the number of the election for nationwide local governments are approx. 5 (times) (= approx. 20/4) for ten years, in terms of national election.

Approximate total number of the national election and local election (in terms of national election.) for ten years.

Approximate total number = $20/3 + 5 = 35/3 = 11.666\dots$ approx. 11.7 (times)

Approximate value of the cost reduction effect by the proposed method for ten years

Approximate value = $3,217,497,482.16 \times 35/3 = 37,537,470,625.2\dots$ 37.5 billion yen

From the above, the proposed electronic admission card of voting station provides the cost reduction effect of approx. 37.5 billion yen for ten years.

5. The Security of the Electronic Voting Admission

5.1. An Overflow of the System Measure of the Server

Measures 1: Election Administration Server should be doubled or multiplied.

Measures 2: All of such data should be downloaded in advance and stored in the terminal at voting place, which are of the information of the voter who are administered by the stations.

5.2 The Measure for Electric Outage of Voting Place

As the illumination becomes insufficient, it is difficult to vote by the existing admission card of voting station.

(There has been no case of electric outage at the stations at the time of implementation of elections)

6. THE ELECTRONIC VOTING ADMISSION AND NETWORK COMPOSITION

There are various types of relationship between voter and voting place. In this proposal of electronic admission card of voting station, we consider the co-existence with the existing admission card of voting station and assume the Type 1. and Type 2 of early voting.

Type 1: Voter are allowed to cast a ballot at the designated one voting station.

(Consideration: this is the existing type and can co-exist with the existing admission card of voting station.)

Type 2: Voter are allowed to select one of the designated plural voting place and to cast a ballot there. It is necessary to develop such a method of counting ballots which meets this type.

(**Consideration:** The Type 2. is an extension of the Type1. It is necessary to strengthen the identification of voter at voting place, by such methods as checking by their facial portrait or identity verification documents "driver license, passport, Basic Resident Register Card and others." In this proposed method, checking by constituent's facial portrait can be added to the identification. As the voting station designated for early voting is under the Type 2, the terminal at the said voting station requires to be allowed to access the information of all the voter which are administered at the said voting station)

Type 3: Voter are allowed to cast a ballot at any voting station.

(**Consideration:** It is necessary to strengthen the identification of voter at voting place.)

7. THE PROTOTYPE OF THE ELECTRONIC VOTING ADMISSION

7.1 The Overview

In order to examine the possibility and effectiveness of the proposed method as described in the Section 2, we prepare the system of electronic admission card of voting station as prototype, and prove /value the system. Administrators input the constituent data into the server. The two-dimensional scanner is a marketed commodity which mounts UBC Interface to be connected to PC and the decoder (the function which decodes the contents of two-dimensional code and change to the original text data) of two-dimensional code. We weigh up the handheld type with which the examiners image in their hand and the stationary type that is placed on desk and others. The constituent data, including the electronic admission card of voting station and the two-dimensional code are sent by e-mail to voter's cell-phone handset at the date set by the server. At the start of the lesson, voter submit such a data of the two-dimensional code on the two-dimensional scanner, which is displayed on their cell-phone handset. The name and others of voter are verified by the constituent data which is included in the two-dimensional code. At this time, the name of voter are registered in the list of voters and displayed on the screen of examiners' terminal (computers such as laptop).

7.2 The Server

The server prepares the two-dimensional code from constituent data and can be put into practice via web soft and scrip.

7.3 The Cell-Phone of Voter

In Figure 2, we show the display sample of the voter' electronic admission card of voting station (other types than this sample can be thought).

On the screen of the cell-phone handset, display is made of the character basic information of voter and the two-dimensional code. The two-dimensional code includes some part of constituent data. The constituent data can be scanned promptly by the two-dimensional scanner due to the use of the function of the two-dimensional code. Security of the constituent data can be enhanced.

The type of two-dimensional code used for is QR Code (QR Code is the trade mark of the DENSO WAVE Co., Ltd.).



Figure 2: An Example of the Display of the Voting Admission Ticket by Using a Cell Phone

7.4 The Terminal at Voting Place

The acceptance terminal at voting place receives such a text data from the two-dimensional scanner, which decodes the contents of the two-dimensional code, and displays the detailed constituent data. In Figure 3, we show the status of use of the examiner terminal in prototype, the two-dimensional scanner and user's cell-phone handset. In case that voter register their facial portrait at the center as optional function, such a facial portrait can be displayed on the screen of the acceptance terminal at voting place, which are downloaded along with the constituent data. The type of facial portrait is a color image in the form of JPEG.



Figure 3: The View of the Experiment of the Voting Admission Ticket by Using the Prototype Software

7.5 The Evaluation of the Prototype

Such a main processing time is the time period that the two-dimensional scanner reads the two-dimensional code from cell-phone handset and the examiner terminal can display the processing results by authentication unit examination, which is spent by examiners to authenticate voter. This is called the Processing Time for Constituent Authentication.

The actual measurement value of Processing Time for Constituent Authentication is less than one second, of all the cell-phone handsets (seven sets) which were used for the experimental test.

We use and compare both of the handheld type and desktop type as two-dimensional scanner. The handheld type has a demerit that needs necessarily manpower due to the reason that the part for imaging should be set out on the two-dimensional code on the screen of cell-phone handset and then scan the data by downing the switch. The desktop type can scan the data automatically only by putting close the screen of cell-phone handset to the two-dimensional scanner. Therefore, the desktop type is superior of this prototype.

8. CONCLUSIONS

We proposed the electronic admission card of voting station by using cell-phone and prepared / valued the direct communication method between cell-phone handset and the acceptance terminal at voting place, prototype and others. The proposed method can be co-existent with the existing admission card of voting station by mail delivery method. In case that this proposed method is implemented, the enhancement of service in elections is expected for voter, and also, a big reduction can be attained, of the printing / mailing costs on the admission card of voting station. In the trail calculation, cost reduction is expected approx. 3.2 billion yen per national election. In the consideration of the number of times of national and local elections, it is expected that the cost effectiveness becomes approx. 37.5 billion yen for ten years.

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